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Are We Using the Most Appropriate Methodologies to Assess the Sensitivity of Rainforest Biodiversity to Habitat Disturbance?

A. Whitworth[1,2,3], R. Pillco Huarcaya[2,3,4], L. Whittaker[2,3], and L. Braunholtz[2,5]

Abstract

Accurately assessing how biodiversity responds in the Anthropocene is vital. To do so, a number of indicator taxa are commonly used to monitor human-impacted forests and the subsequent recovery of their biodiversity. This makes monitoring more economically feasible, yet only valuable if the responses observed truly reflect the status of biodiversity. Many challenges exist for getting this monitoring right, including choosing the most effective indicators and ultimately choosing the most appropriate methods to capture trends. We have reason to believe that the methods currently used to assess human-impacted tropical forest might be misrepresenting trends related to the degree of impact of disturbance to biodiversity and to the value of secondary forests for biodiversity conservation. Using recent case studies that assessed butterflies, we challenge the paradigm that fruit-baited butterfly traps are the best method for assessing human-impacted tropical forests, and that their use solely along the forest floor is underestimating the impacts to biodiversity in tropical forests. We suggest that alternative or additional methods could provide a more representative picture of the overall butterfly biodiversity responses to human-impacted tropical forests and that similar assessments of other groups and methods should be carried out.

Keywords

methods, biodiversity surveys, tropical forest, bait choice, vertical strata, paradigms, Lepidoptera, structural complexity

Commentary to: Whitworth, A., Pillco Huarcaya, R., Mercado Gonzalez, H., Braunholtz, L., Macleod., R. (2018). Food for thought. Rainforest carrion-feeding butterflies are more sensitive indicators of disturbance history than fruit feeders. *Biodiversity Conservation, 217*, 383–390.

Cost limitations and short field times within the tropics have driven the need to search out cost-effective indicators of tropical disturbance (Gardner et al., 2008). Yet, how do different methodologies that we use for biodiversity assessments of tropical forests influence the results that we detect and ultimately our interpretations about the value of impacted or recovering landscapes for biodiversity conservation? A recent study by Whitworth, Pillco Huarcaya, Gonzalez Mercado, Braunholtz, and MacLeod (2018) tests the paradigm that fruit-feeding butterflies are the most suitable indicator group of Lepidoptera with which to assess human-mediated rainforest disturbance. Despite previous studies suggesting that baiting traps with carrion results in higher capture rates and displays a greater representation of the overall community (Hamer et al., 2006), it has become the norm for studies in tropical rainforest to use fermented fruit-baited traps to assess the impact of habitat

[1]Institute of Biodiversity, Animal Health and Comparative Medicine, College of Medical, Veterinary and Life Sciences, University of Glasgow, UK
[2]The Crees Foundation, Cusco, Perú
[3]Osa Conservation, Washington, DC, USA
[4]Universidad Nacional San Antonio Abad del Cusco, Perú
[5]School of Natural and Environmental Sciences, Newcastle University, UK

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Corresponding Author:
A. Whitworth, University of Glasgow, Room 303, Graham Kerr Building, University Avenue, Glasgow G12 8QQ, UK.
Email: andy.w.whitworth@gmail.com

disturbance on Lepidopteran biodiversity (see Table 1). However, in their comparison of carrion- and fruit-baited traps, Whitworth et al. (2018) show that in addition to higher capture rates and attracting a wider array of the community, carrion-baited traps are more sensitive to rainforest disturbance effects and less susceptible to seasonal fluctuations. They therefore suggest that the community attracted to carrion-baited traps performs better as a biodiversity indicator group than the community associated with fruit-baited traps. Furthermore, the continued use of fermented fruit-baited traps alone could underestimate the impact of habitat disturbance or misrepresent the value of regenerating forest for biodiversity conservation.

The key finding of this study is not that different baits detect different community subsets, but that they indicate different degrees of disruption to biodiversity in relation to habitat disturbance. This varying or even contrasting pattern within a taxon, as a result of methodological design, can alter our interpretation of the levels of impact by human disturbance or of the value of recovering landscapes for biodiversity conservation. Subsequently, this can give rise to inappropriate guidelines for the management of rainforest habitats, especially those with the aim to conserve or recover biodiversity. Assessments of butterflies only using fruit-baited traps in Manu, for example, would underestimate the impacts of habitat disturbance to Lepidopteran biodiversity compared with an assessment carried out using carrion-baited traps. Such within-site methodological differences have also been detected for other taxa including birds (Barlow, Mestre, Gardner, & Peres, 2007) and amphibians (Whitworth, Villacampa, Rojas, Downie, & Macleod, 2017). Barlow, Mestre, et al. (2007) suggest that using mist nets as opposed to point counts indicates a higher value of secondary forest for bird species richness. Mist net sampling detected an equivalent number of bird species to that of an old-growth forest, whereas point counts detected diminished species richness in secondary forest. Whitworth et al. (2017) detected no difference in amphibian diversity between regenerating secondary growth and selectively logged forest when using pitfall traps, whereas nocturnal transects indicated that amphibian biodiversity was significantly lower in secondary growth forest compared with selectively logged forest.

Unlike the study by Whitworth et al. (2018), neither of these studies on amphibians (Whitworth et al., 2017) and birds (Barlow, Mestre, et al., 2007) differs as a result of the food resource offered as bait but rather in relation to vertical dimensions that the researchers sampled. The structural complexity of tropical rainforests gives rise to unique subsets of biodiversity at different vertical strata, and these likely respond differently to habitat disturbance. These vertical strata are severely underresearched compared with the terrestrial realm, and a recent global review suggests a key area of focus should be assessments encompassing all vertical strata over different disturbance gradients (Nakamura et al., 2017). Considering butterflies once more as an example (again sampled with fruit bait as paradigm dictates), studies from the Amazonian regions of Ecuador, Perú and Brasil and from Sulawesi have observed higher species richness in the understorey compared with the rainforest canopy (Barlow, Overal, Araujo, Gardner, & Peres, 2007; DeVries & Walla, 2001; Fermon, Waltert, Vane-Wright, & Mühlenberg, 2005; Whitworth, Villacampa, Brown, & Huarcaya, 2016). But do the communities in these different vertical levels respond to habitat disturbance to the same degree? Despite our understanding of vertical stratification, to our knowledge, only two studies evaluating the effects of habitat change on Lepidopteran biodiversity have sampled across more than two vertical levels (and just one of these used both carrion- and fruit-baited traps; Fermon et al., 2005; Whitworth et al., 2016). Whitworth et al. (2016) found that differences between rainforest of different disturbance history (complete clearance vs. selective logging) were most notable within the canopy. Regenerating cleared forest had 47% lower canopy species richness than selectively logged forest, while the difference between the two in the terrestrial strata was 30%.

This variation in community responses to habitat disturbance between different vertical strata of the rainforest

Table 1. Modified From Whitworth et al. (2018; Supplementary Material).

Studies carried out across vertical strata	Studies carried out using both carrion and fruit bait	Studies carried out using both baits types and carried out across vertical strata
8	2	1

Note. Summary of studies found in a literature review to assess the prevalence of butterfly studies that include carrion-baited traps in their methodology on the ISI Web of Science database (http://wok.mimas.ac.uk/). Search terms focused on tropical butterfly studies, and those that assessed anthropogenic disturbance. Twenty studies fitted the criteria and summarized here are the number of studies that sampled using carrion and fruit bait, the number that sampled across multiple strata, and the number that used both these methods.

has been shown for groups other than butterflies, including communities of ants (Klimes et al., 2012) and birds (Rodríguez-Pérez, Herrera, & Arizaga, 2018), and a single species of dung beetle (Tregidgo, Qie, Barlow, Sodhi, & Lee-Hong Lim, 2010). Whereas invertebrates display higher sensitivity to human disturbance within the canopy, birds show the opposite trend, with canopy-associated bird species tolerating habitat disturbance better than their understory counterparts. This suggests that variation in biodiversity responses to habitat disturbance between vertical strata is not standardized across taxa, yet each of study shows different degrees of sensitivity and higher levels of impact in one vertical stratum over another. The differences detected in the response of amphibians in relation to historic habitat disturbance surveyed by pitfall traps versus nocturnal transects in the Peruvian Amazon likely relates to these vertical stratification differences, with pitfalls targeting the terrestrial leaf-litter community and transects by observers comprising a greater arboreal component of the community (Whitworth et al., 2017).

Crucial to each of the aforementioned studies is that they are conducted over a within-site scale (i.e., at the same study site, and at the same time). While limiting in terms of general applicability across regions, this allows us to be more confident that the differences detected relate directly to the methods used. Future studies across multiple sites that assess these observed patterns would be useful to determine whether such within-site case studies are widely representative. For meta-analyses that aim to gather data from studies, using varied methodologies then strategies can be developed at the within-site site scale to account for methodological differences and then incorporated into associated models (Van Gemerden, Etienne, Olff, Hommel, & Van Langevelde, 2005).

As the deadline for the Convention of Biological Diversity's (2010) Aichi Biodiversity Targets are fast approaching, monitoring biodiversity has never been so important. As we face dramatic biodiversity declines in the current era, appropriately termed the Anthropocene (Moreno et al., 2017), we need to be able to accurately determine biodiversity baselines and rapidly detect disruptions to these patterns. However, accurate and rapid methods are essential not only to map the impacts to biodiversity as a result of habitat disturbance but also to assess the efficacy of our solutions. Restoration and rewilding approaches are being implemented globally, and the right tools to accurately and efficiently monitor our successes, or failures, are urgently needed (Perring et al., 2015).

If we are to best inform environmental and developmental policies for biodiversity conservation strategies within rainforests, and successfully manage recovering forests to support biodiversity, then we must select appropriate indicator groups with which to carry out assessments and monitoring (Lawton et al., 1998). A key part of this involves carefully selecting the most appropriate methods to target these groups. We should further question paradigms that exist for prevailing methods, as Whitworth et al. (2018) and others have done (Barlow, Mestre, et al., 2007), and continue to explore how biodiversity within the upper reaches of the rainforest canopy might be differentially impacted to those close to the ground (Nakamura et al., 2017). If we utilize methodologies with precision that accurately assess habitat disturbance, we will enhance our ability to predict how forest ecosystems respond to human disturbances and recovery interventions at multiple scales. Most importantly we can avoid dangerously underestimating human-mediated impacts to biodiversity.

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